# Chemical Elements in Electronic Cigarette Solvents and Aerosols Inhibit Mitochondrial Reductases and Induce Oxidative Stress.

**Journal:** Nicotine Tob Res

**Publication Year:** 2020

**Authors:** Monique Williams, Jesse Ventura, Antonio Loza, Yuhuan Wang, Prue Talbot

**PubMed link:** 33320250

**Funding Grants:** CSUSB Bridges to Stem Cell Research

**Public Summary:**
Chemical elements and their toxicity were evaluated in electronic cigarette (EC) solvents, fluids, and aerosols. AIMS AND METHODS: Element identification and quantification in propylene glycol (PG), glycerin (G), refill fluids before and after use, and aerosols was done using inductively coupled plasma optical emission spectrometry. Cytotoxicity and oxidative stress were evaluated using in vitro assays. RESULTS: Seven elements were present in PG, G, and popular refill fluids, and they transferred to aerosols made with ECs. Selenium was in all products (0.125-0.292 mg/L), while arsenic, aluminum, and tin were frequently in solvent and refill fluid samples at lower concentrations. Iron, chromium, copper, nickel, zinc, and lead were only detected in fluid after EC use, indicating they came from heated atomizers. Elements transferred most efficiently to aerosols made with second-/third-generation ECs. Of the elements in fluid, selenium and arsenic were the most cytotoxic to human bronchial epithelial cells (BEAS-2B) and pulmonary fibroblasts in the 3-(4,5-dimethylthiazolyl-2)-2,5-diphenyltetrazolium bromide assay. Selenium increased superoxide production in mitochondria and nucleoli and elevated selenoprotein H in nucleoli of BEAS-2B cells at concentrations found in EC aerosols (10 nM or 0.002 mg/L). CONCLUSIONS: Elements in EC aerosols came from both e-fluids and atomizing units. Within second-/third-generation products, transfer became more efficient as power increased. In vitro responses occurred at concentrations of selenium found in some EC aerosols. Human exposure to chemical elements in ECs could be reduced by regulating (decreasing) allowable EC power and by improving the purity of PG and G. IMPLICATIONS: PG, G, refill fluids, and e-fluids contained potentially toxic chemical elements that transferred to aerosols. Transfer was more efficient in second- and third-generation EC products and increased as power increased. Selenium and arsenic were the most cytotoxic of the elements tested in the 3-(4,5-dimethylthiazolyl-2)-2,5-diphenyltetrazolium bromide assay. Selenium tetrachloride-induced oxidative stress in BEAS-2B cells, but not in human pulmonary fibroblasts. All fluids contained selenium above the concentration that induced oxidative stress in human bronchial epithelial cells. Selenium increased superoxide in mitochondria and nucleoli and increased selenoprotein H, a redox responsive DNA-binding protein that is upregulated by superoxide and an indicator of nucleolar stress. EC users are exposed to elements in aerosols, which may with chronic exposure contribute to diseases associated with oxidative stress.

**Scientific Abstract:**
INTRODUCTION: Chemical elements and their toxicity were evaluated in electronic cigarette (EC) solvents, fluids, and aerosols. AIMS AND METHODS: Element identification and quantification in propylene glycol (PG), glycerin (G), refill fluids before and after use, and aerosols was done using inductively coupled plasma optical emission spectrometry. Cytotoxicity and oxidative stress were evaluated using in vitro assays. RESULTS: Seven elements were present in PG, G, and popular refill fluids, and they transferred to aerosols made with ECs. Selenium was in all products (0.125-0.292 mg/L), while arsenic, aluminum, and tin were frequently in solvent and refill fluid samples at lower concentrations. Iron, chromium, copper, nickel, zinc, and lead were only detected in fluid after EC use, indicating they came from heated atomizers. Elements transferred most efficiently to aerosols made with second-/third-generation ECs. Of the elements in fluid, selenium and arsenic were the most cytotoxic to human bronchial epithelial cells (BEAS-2B) and pulmonary fibroblasts in the 3-(4,5-dimethylthiazolyl-2)-2,5-diphenyltetrazolium bromide assay. Selenium increased superoxide production in mitochondria and nucleoli and elevated selenoprotein H in nucleoli of BEAS-2B cells at concentrations found in EC aerosols (10 nM or 0.002 mg/L). CONCLUSIONS: Elements in EC aerosols came from both e-fluids and atomizing units. Within second-/third-generation products, transfer became more efficient as power increased. In vitro responses occurred at concentrations of selenium found in some EC aerosols. Human exposure to chemical elements in ECs could be reduced by regulating (decreasing) allowable EC power and by improving the purity of PG and G. IMPLICATIONS: PG, G, refill fluids, and e-fluids contained potentially toxic chemical elements that transferred to aerosols. Transfer was more efficient in second- and third-generation EC products and increased as power increased.

Selenium and arsenic were the most cytotoxic of the elements tested in the 3-(4,5-dimethylthiazolyl-2)-2,5-diphenyltetrazolium bromide assay. Selenium tetrachloride-induced oxidative stress in BEAS-2B cells, but not in human pulmonary fibroblasts. All fluids contained selenium above the concentration that induced oxidative stress in human bronchial epithelial cells. Selenium increased superoxide in mitochondria and nucleoli and increased selenoprotein H, a redox responsive DNA-binding protein that is upregulated by superoxide and an indicator of nucleolar stress. EC users are exposed to elements in aerosols, which may with chronic exposure contribute to diseases associated with oxidative stress.

---